Front-Mountain Interactions over the Intermountain West

Atmos 5210/6210

Synoptic–Dynamic Meteorology II

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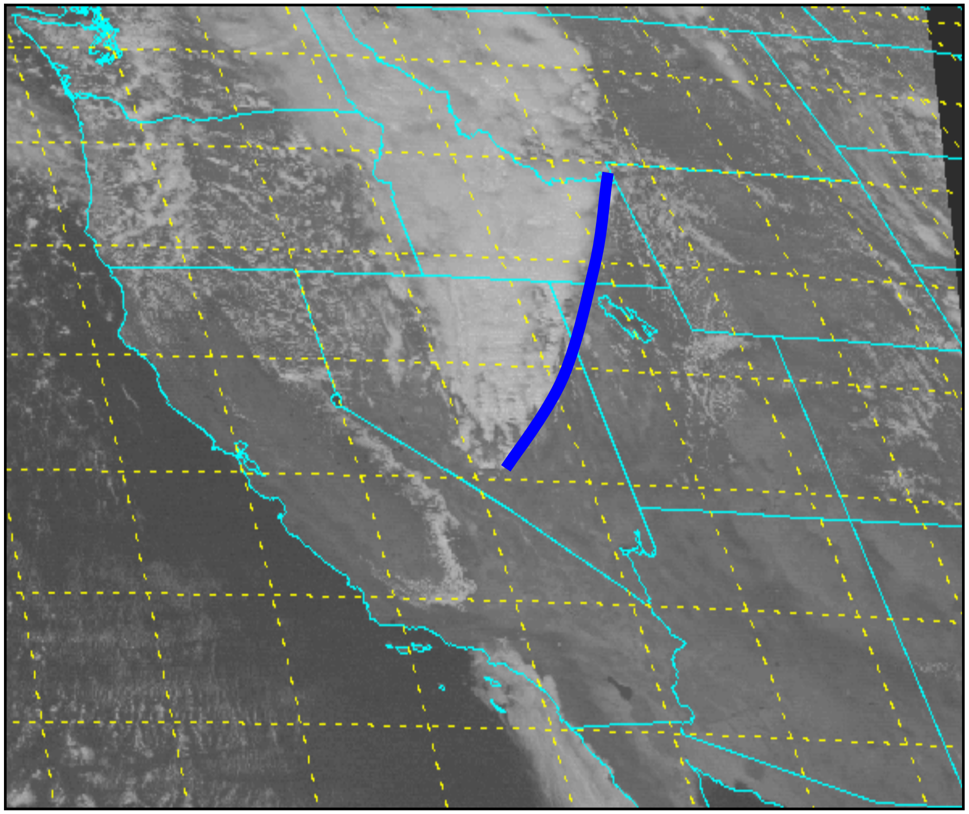
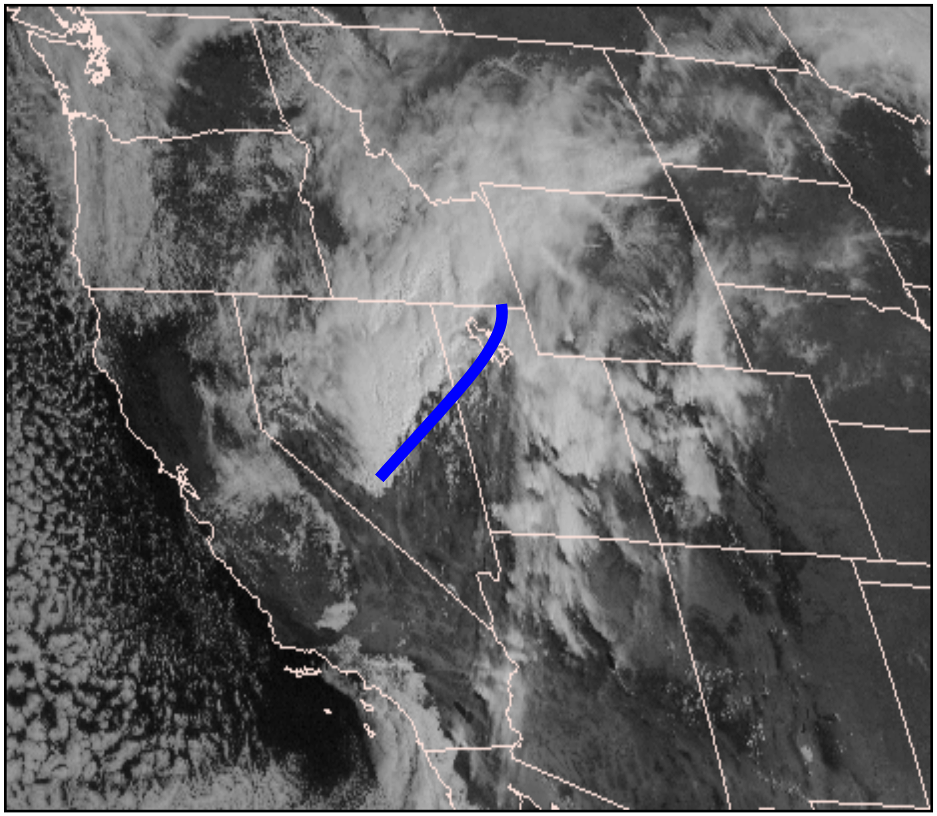
Sample Events



<u>5 Jun 1995</u>

Wind gusts > 40 m s^{-1}

$15 mil in property damage



<u>15 Apr 2002</u>

Temperatures fall 7°C in 10 s

& 19°C in 2 h

Wind gusts > 30 m s^{-1}

Blowing dust closes US-6

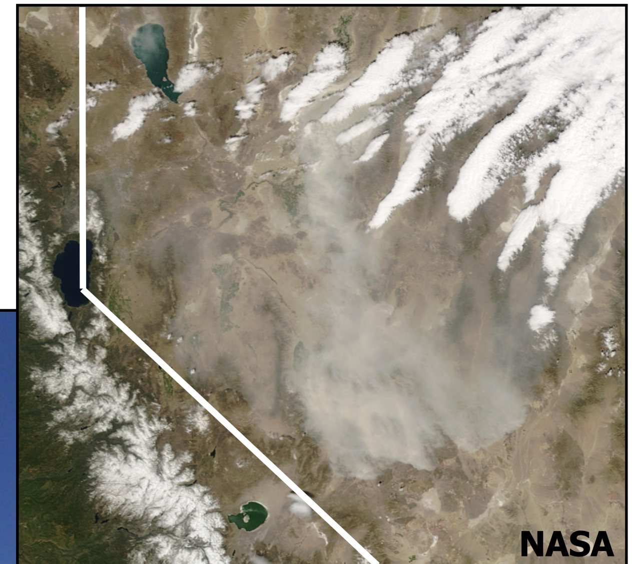
Impacts

- High winds
- Dust storms
- Power outages
- Wildfire runs
- Property damage
- Heavy snow

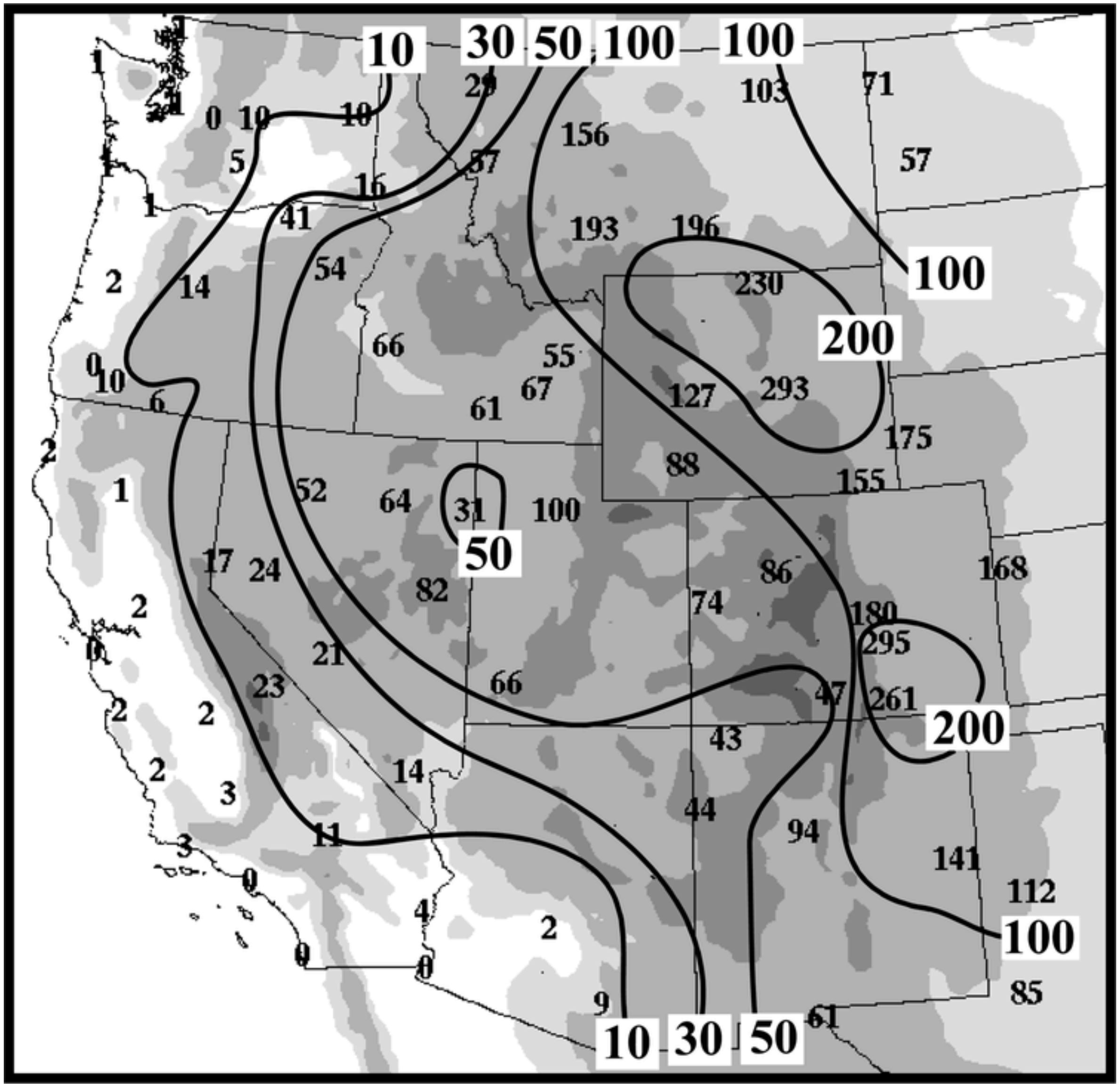
Climate Impacts

Wind-blown dust shortens the duration of mountain snow cover by one month

- Painter et al. (2007)



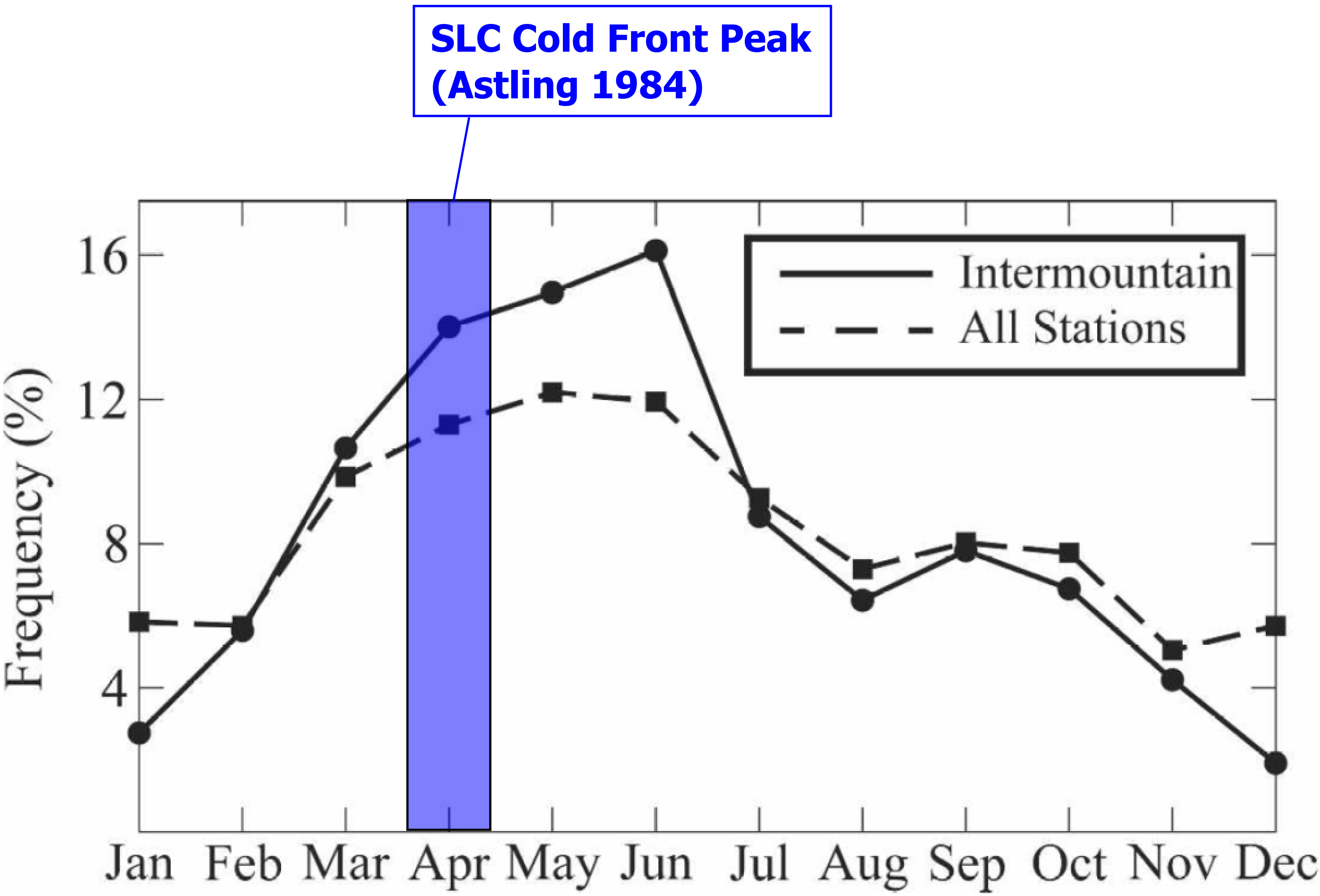
The Frontal Breeding Ground



Strong Cold Fronts 79-03
- > 7° C fall
- > 3 hPa rise
- > 6° C/500 km @ 700 mb

Source: Shafer and Steenburgh (2008)

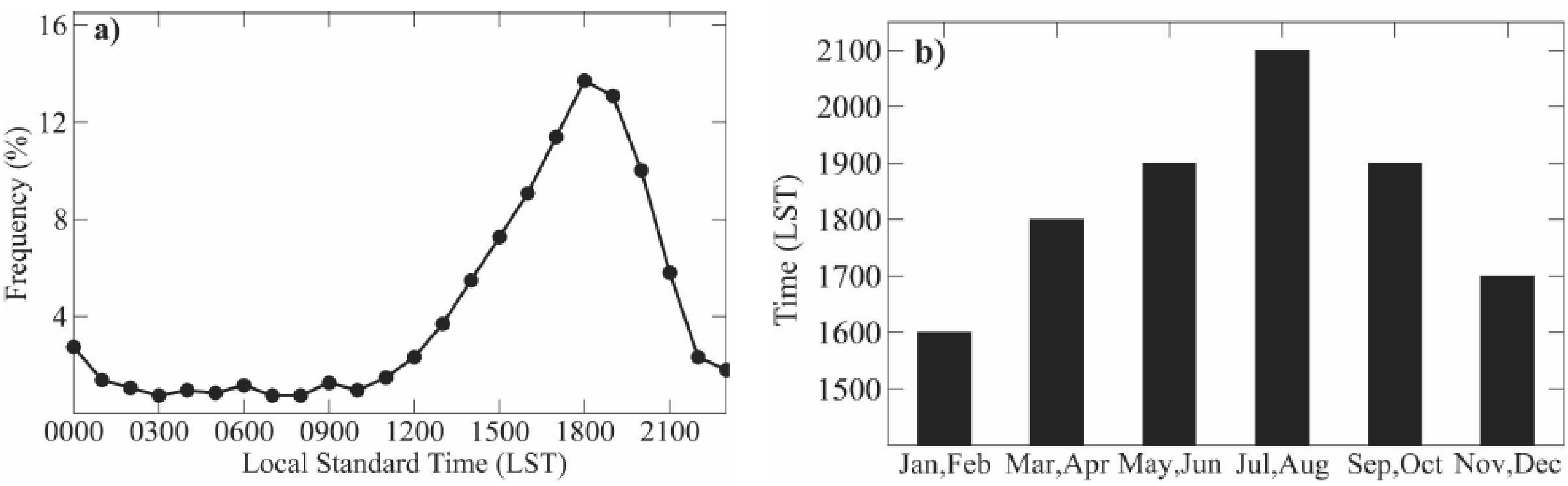
Seasonality



Cold fronts less common, but more intense as warm season approaches

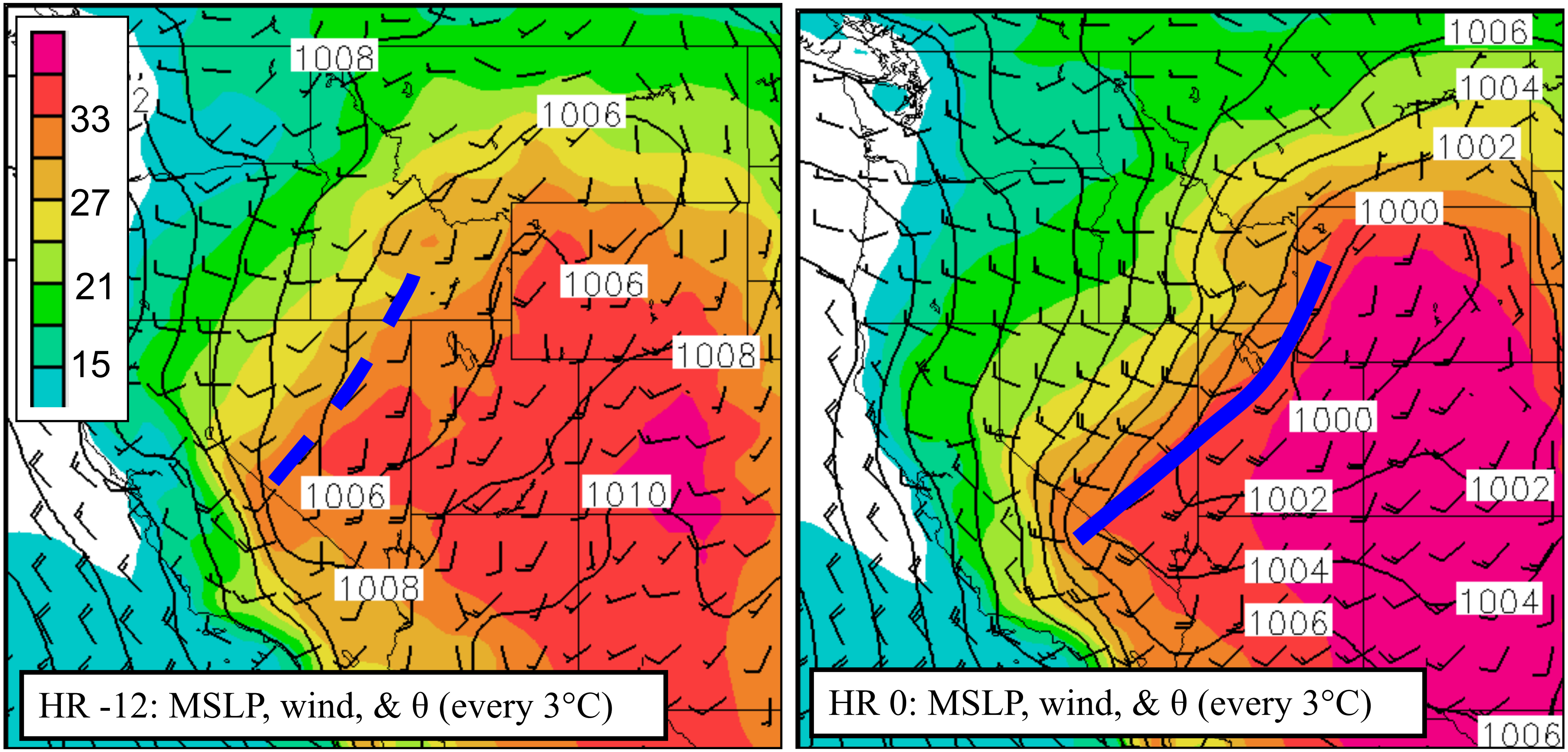
Source: Shafer and Steenburgh (2008)

Diurnal Variability



Source: Shafer and Steenburgh (2008)

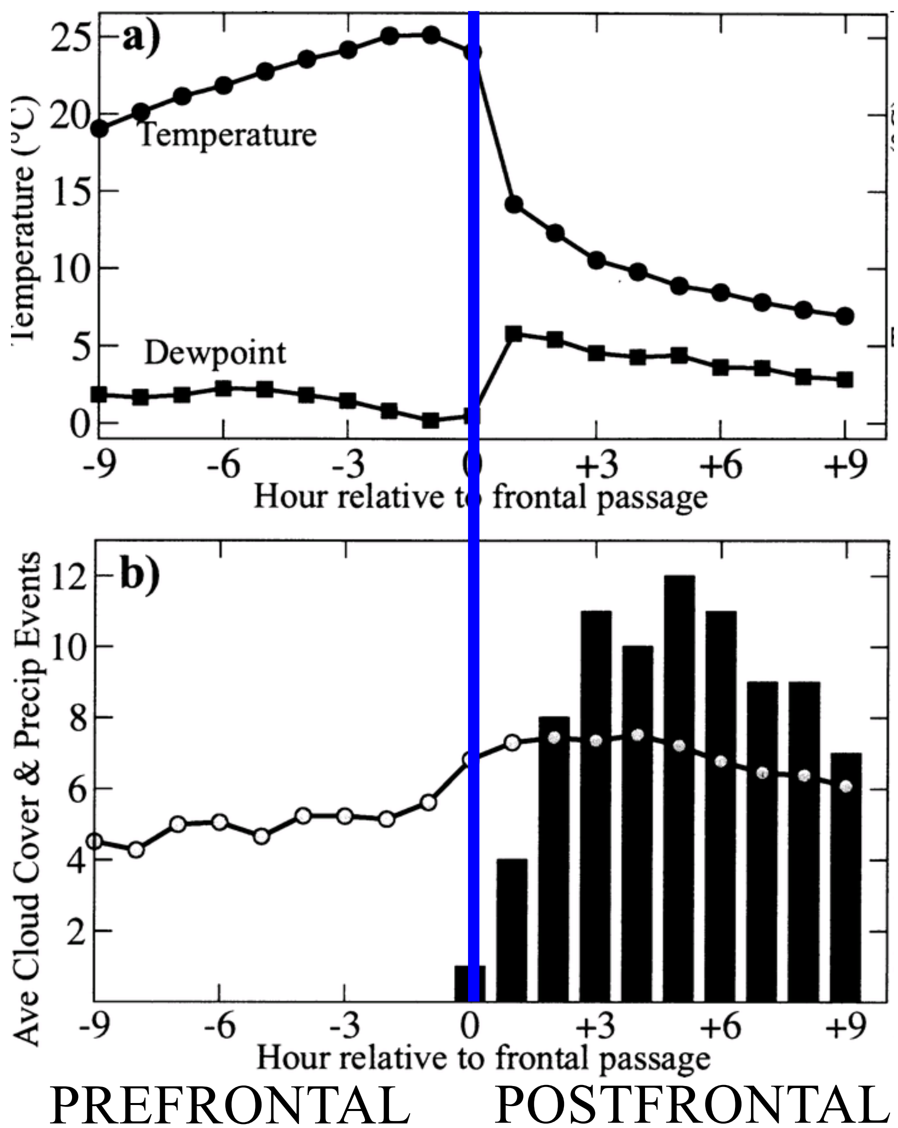
Composite Evolution for SLC



- Frontal development occurs along Great Basin Confluence Zone
- Represents boundary between warm, dry Intermountain air and cooler Pacific air

Source: Shafer and Steenburgh (2008)

Clouds and Precipitation @ SLC



Mean prefrontal Ceiling = 4 km

Mean postfrontal Ceiling = 1.2 km

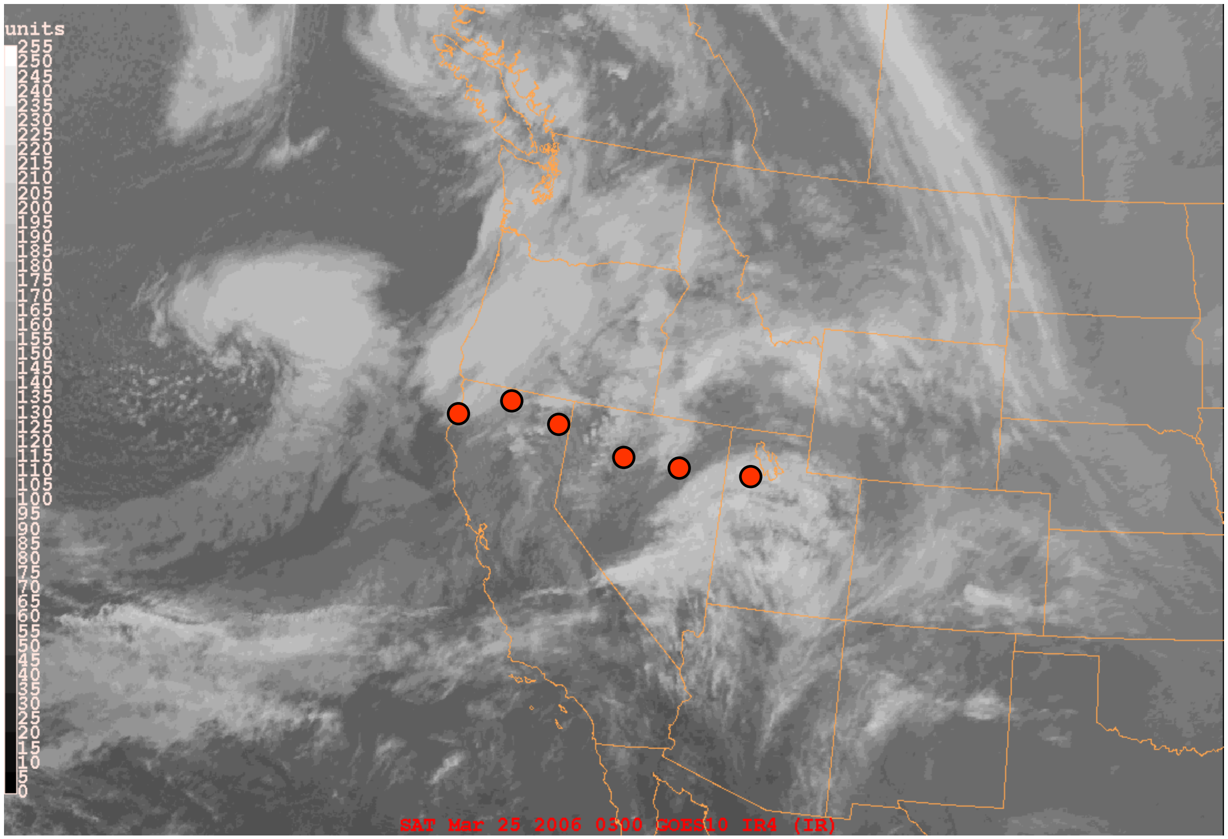
Source: Shafer and Steenburgh (2008)

Climatological Summary

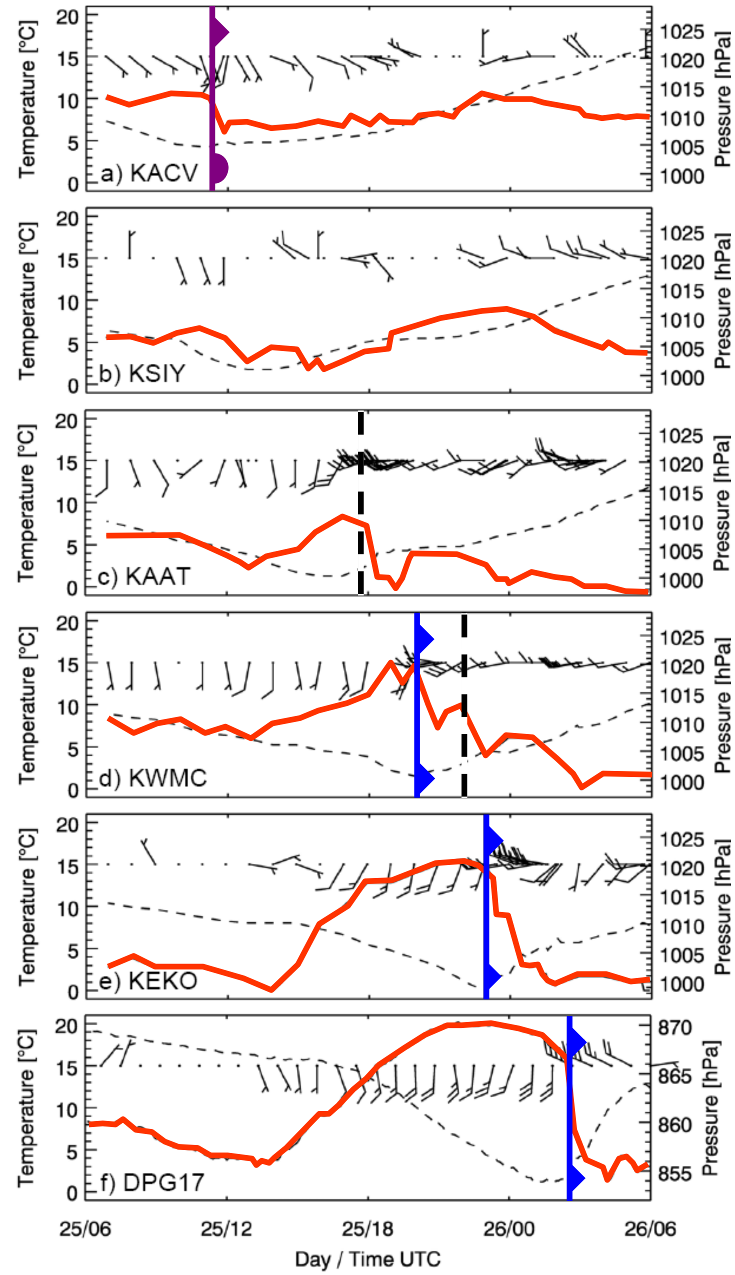
- Strong cold-front frequency increases across Intermountain West, reaching a max at SLC
- Incipient frontal development occurs along confluent flow downstream of Sierra (i.e., the GBCZ)
- Differential surface heating from inhomogeneous cloud cover and post-frontal precipitation may contribute to frontal sharpening


SAINTS
AND
SINNERS

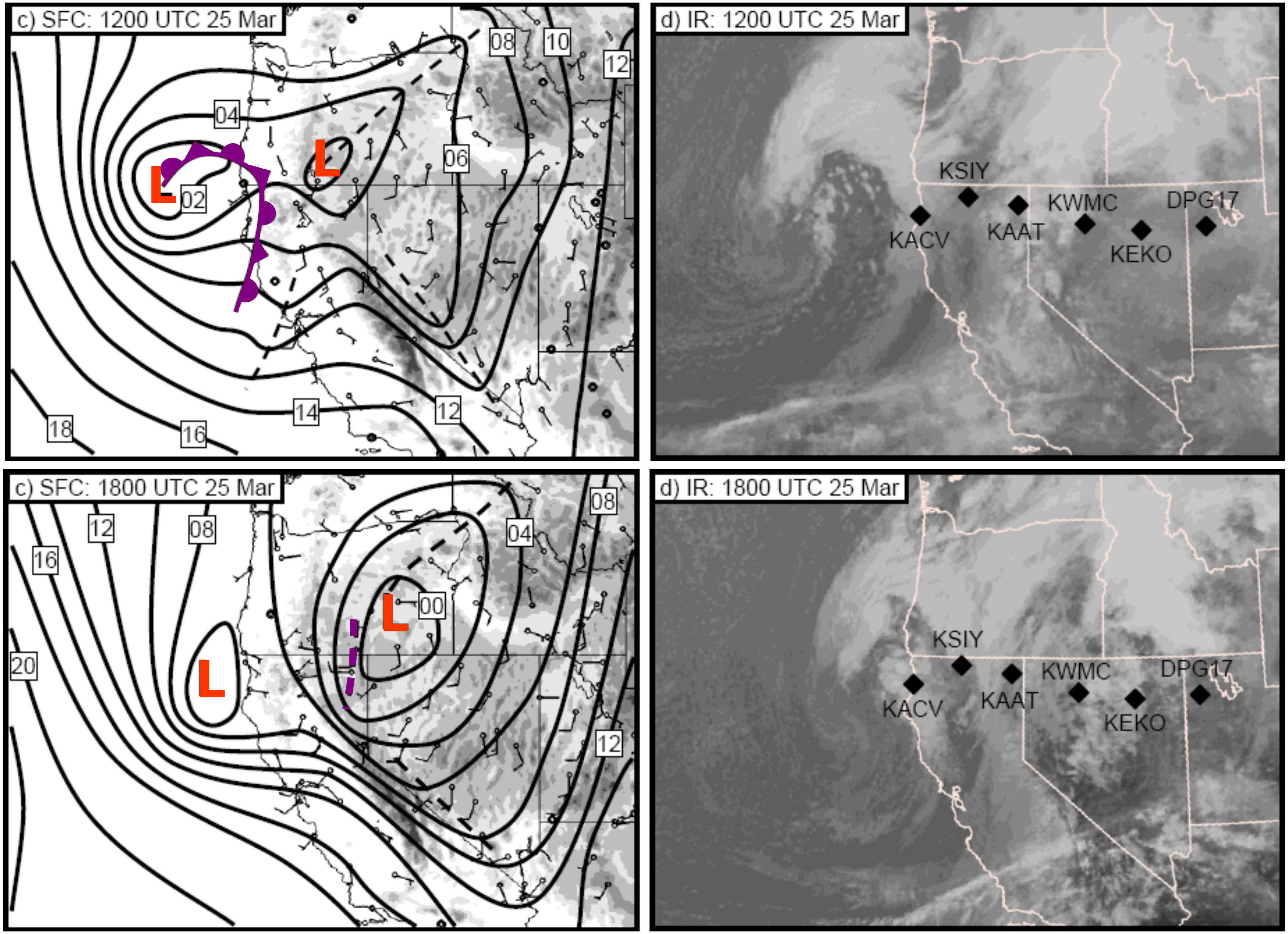
Saints and Sinners Storm



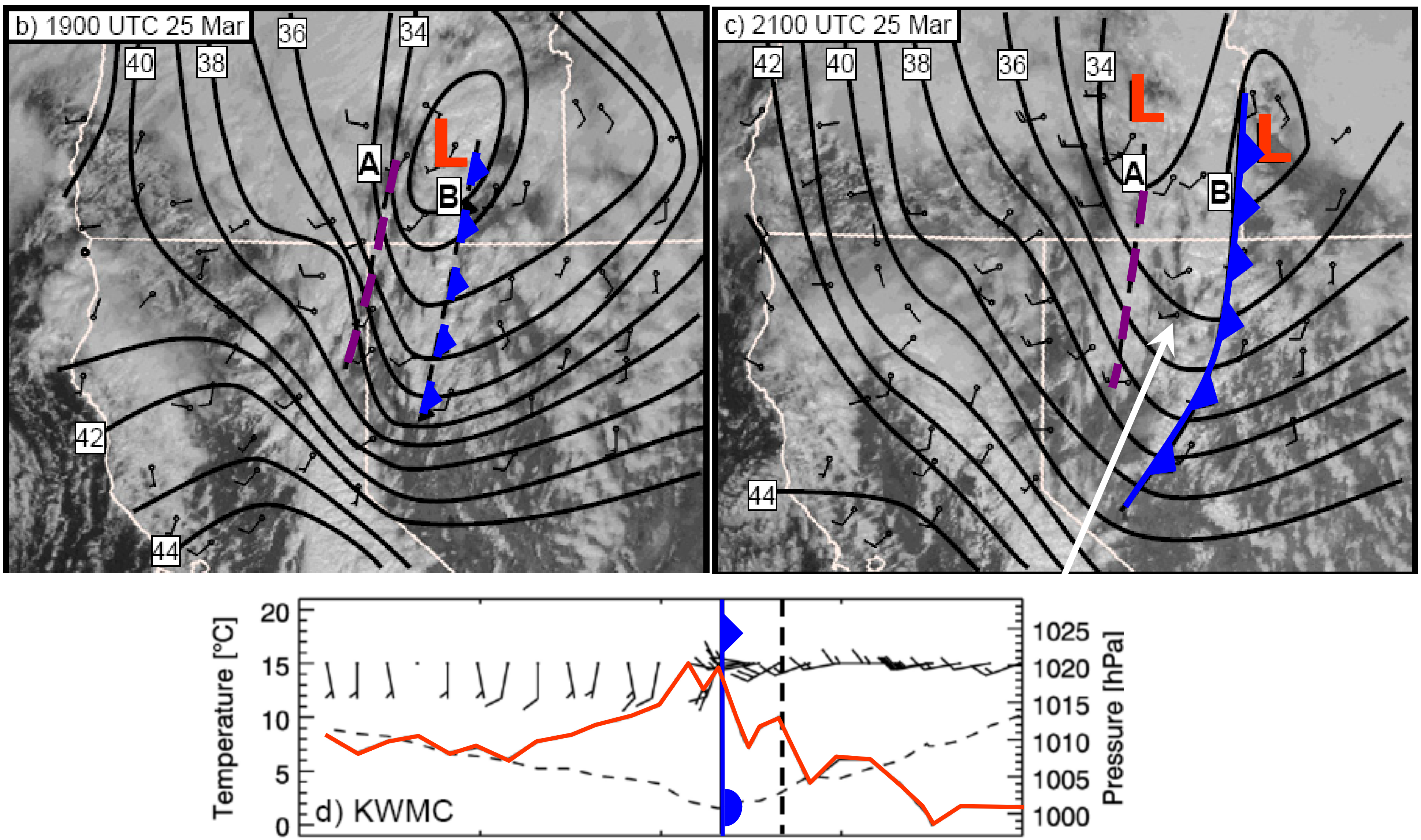
ACV to SLC
16 h
60 km/h



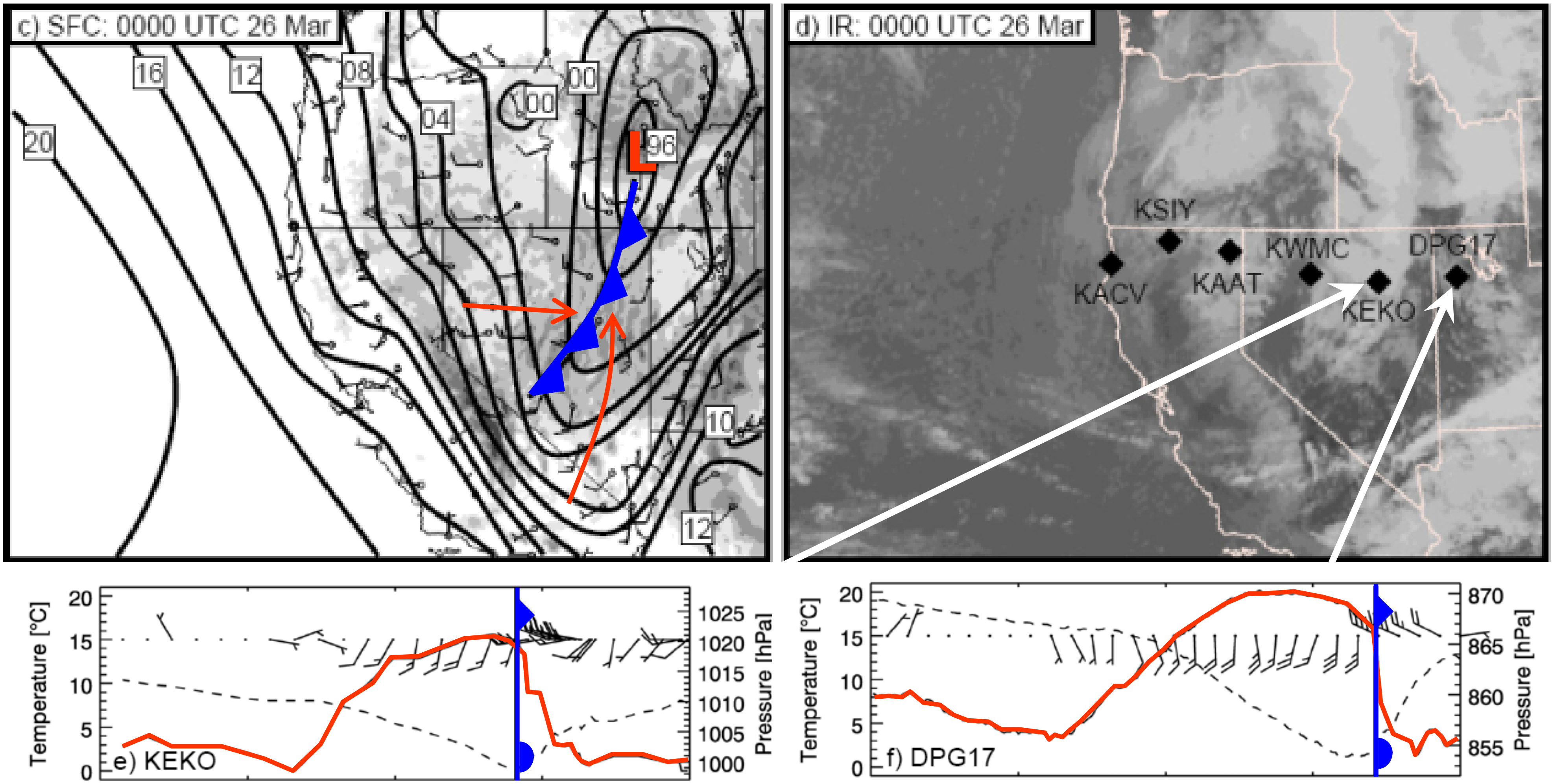
Discrete Propagation



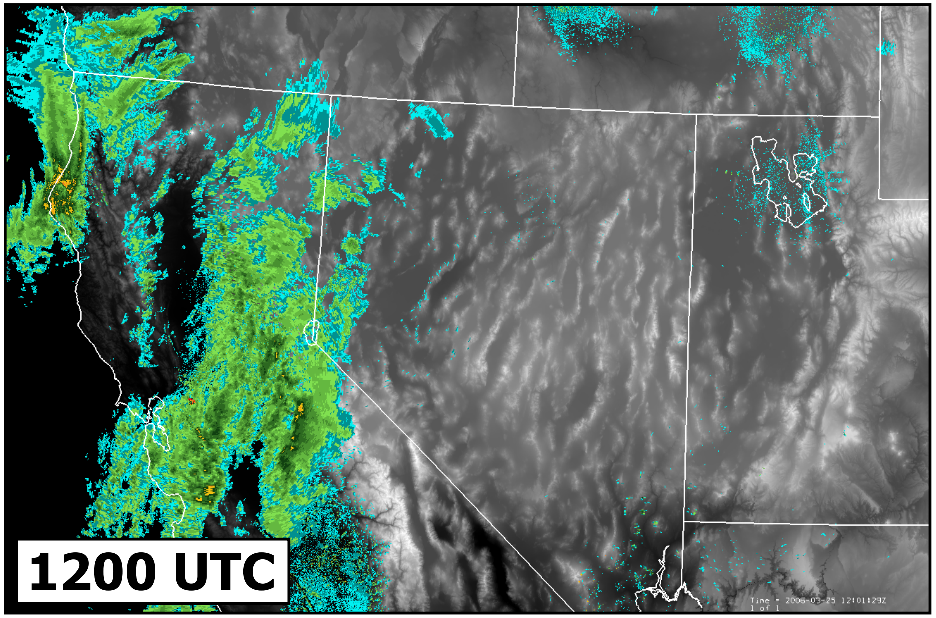
Discrete Propagation

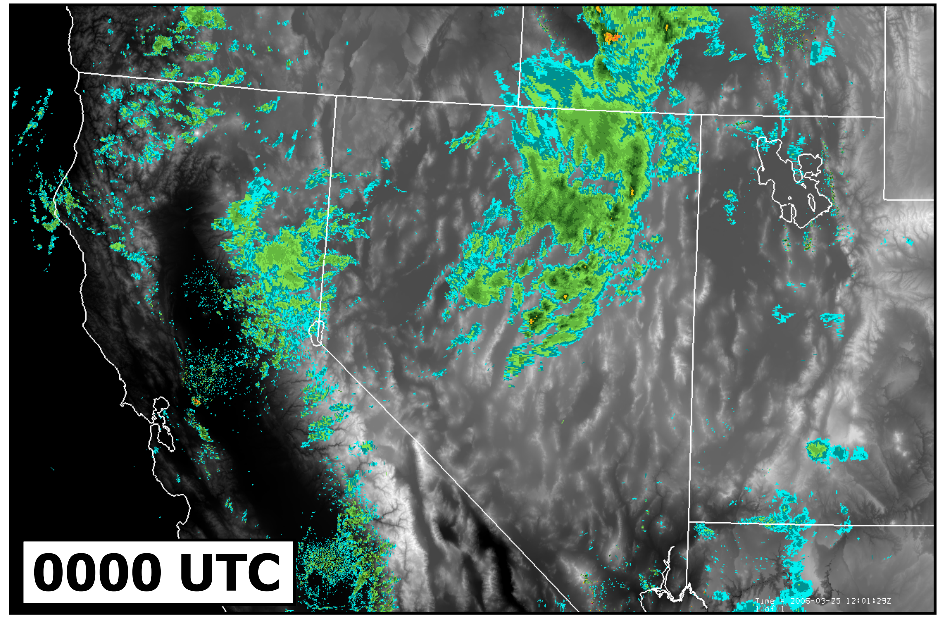


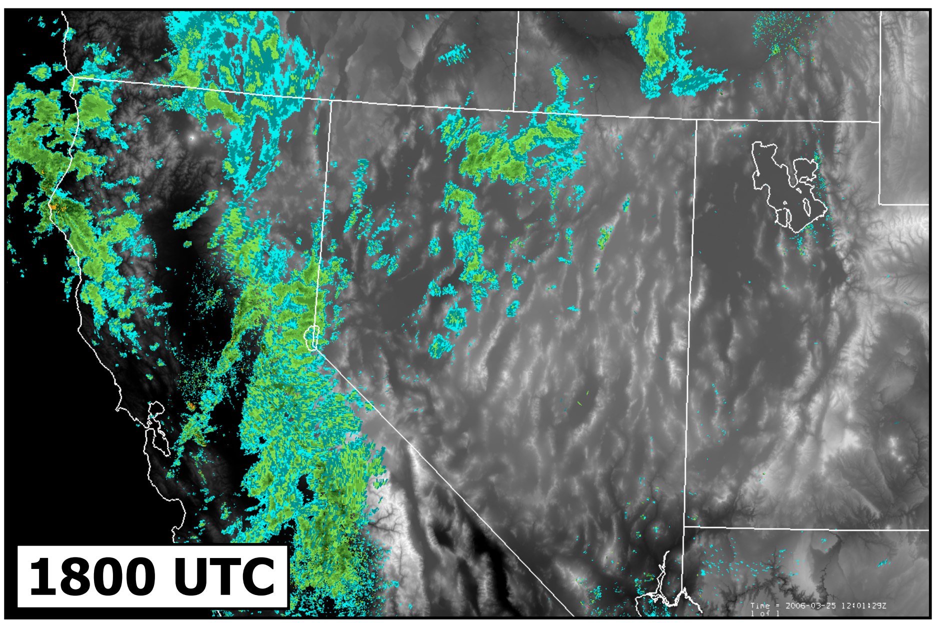
Discrete Propagation

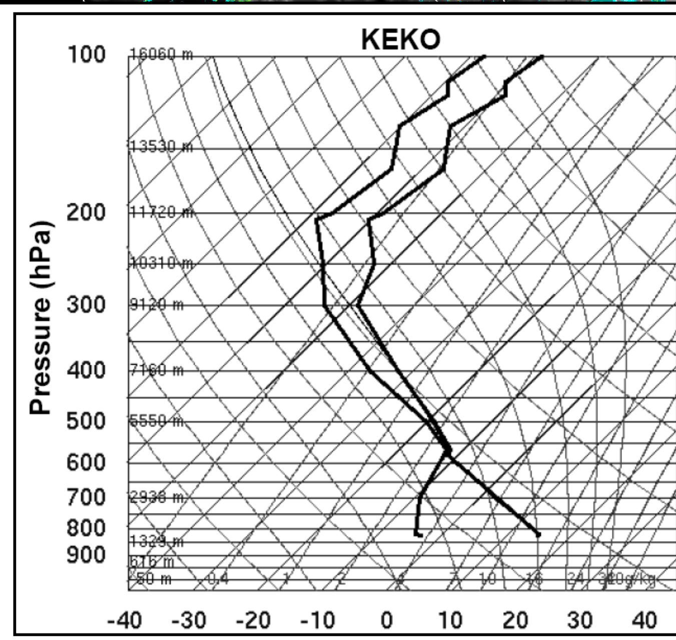


Discrete Propagation

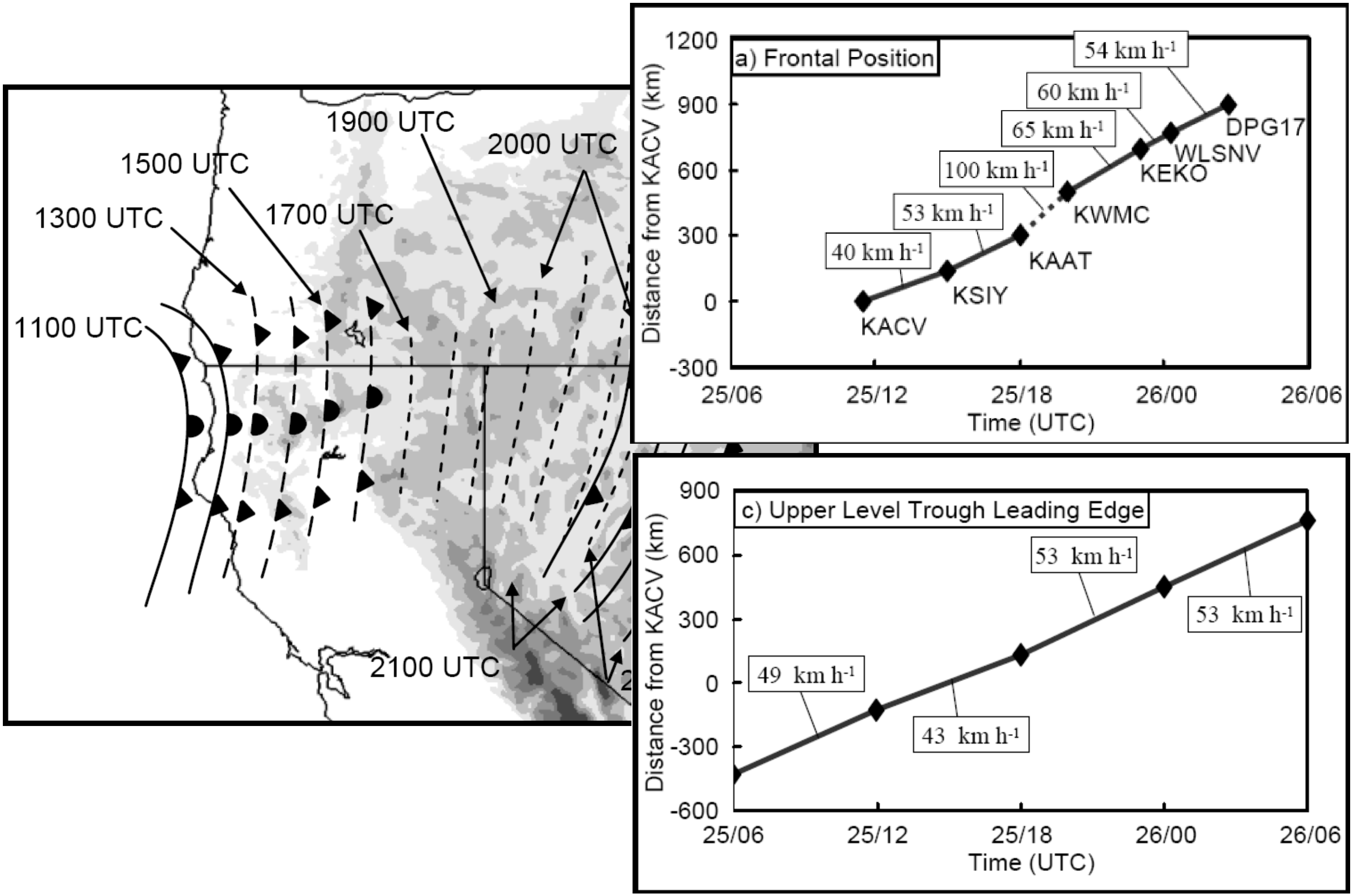




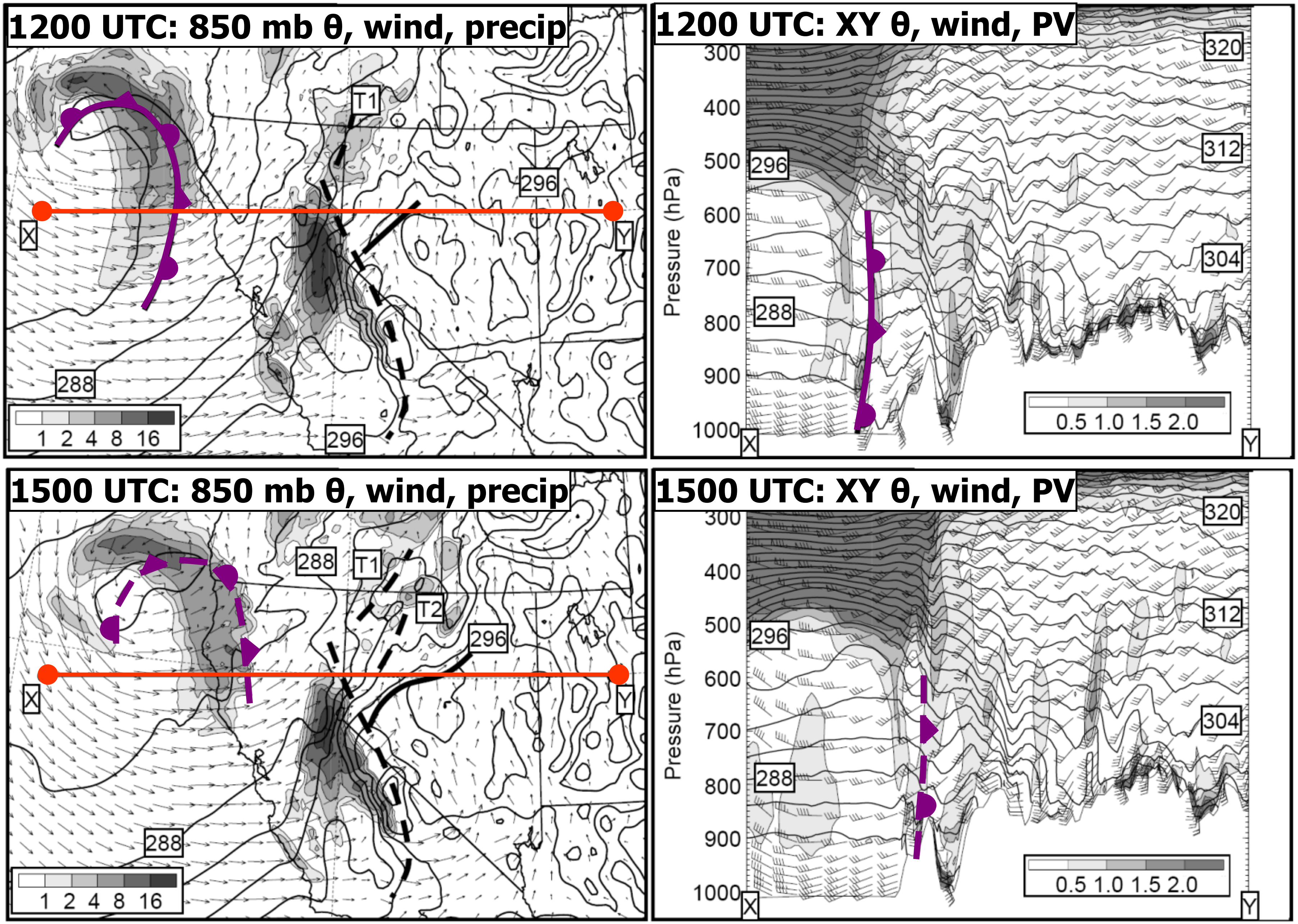




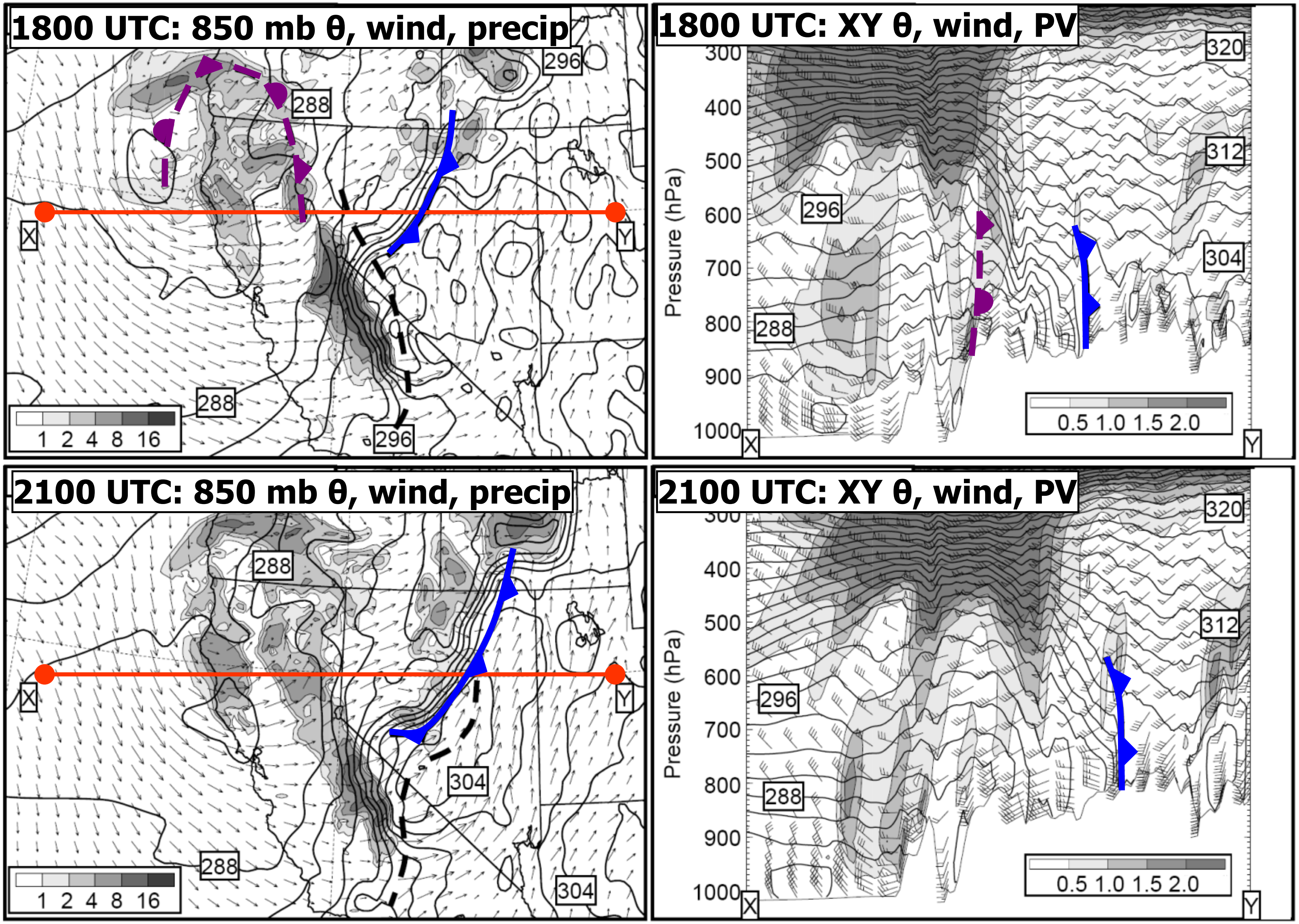
Discrete Propagation



WRF


1200 UTC: 850 mb θ, wind, precip
T1
296
288
296
X
Y
1 2 4 8 16
1200 UTC: XY θ, wind, PV
Pressure (hPa)
300
400
500
600
700
800
900
1000
296
288
320
312
304
0.5 1.0 1.5 2.0
1500 UTC: 850 mb θ, wind, precip
288
T1
T2
296
288
1500 UTC: XY θ, wind, PV

WRF


1800 UTC: 850 mb θ, wind, precip
288
296
X
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1 2 4 8 16
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300
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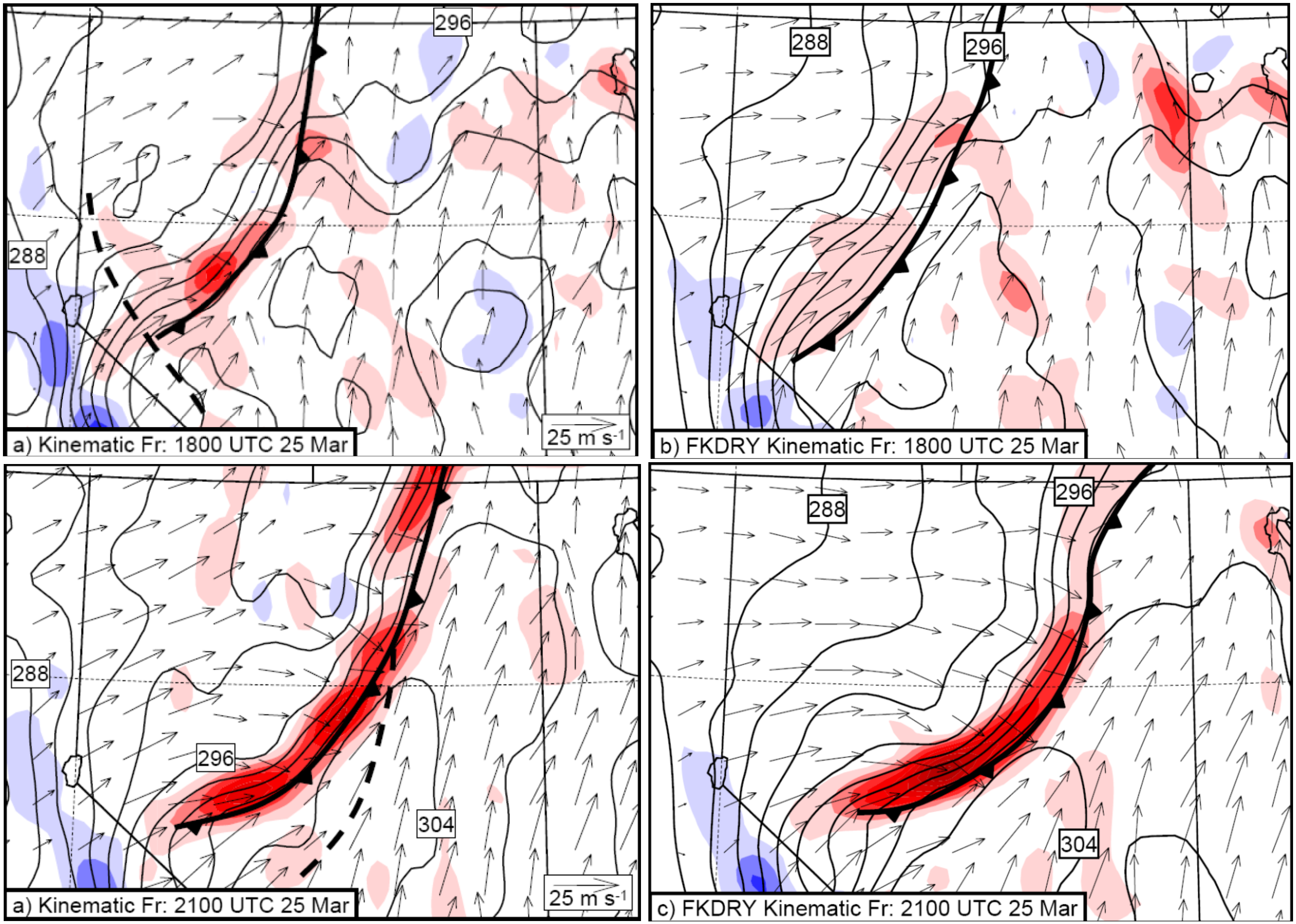
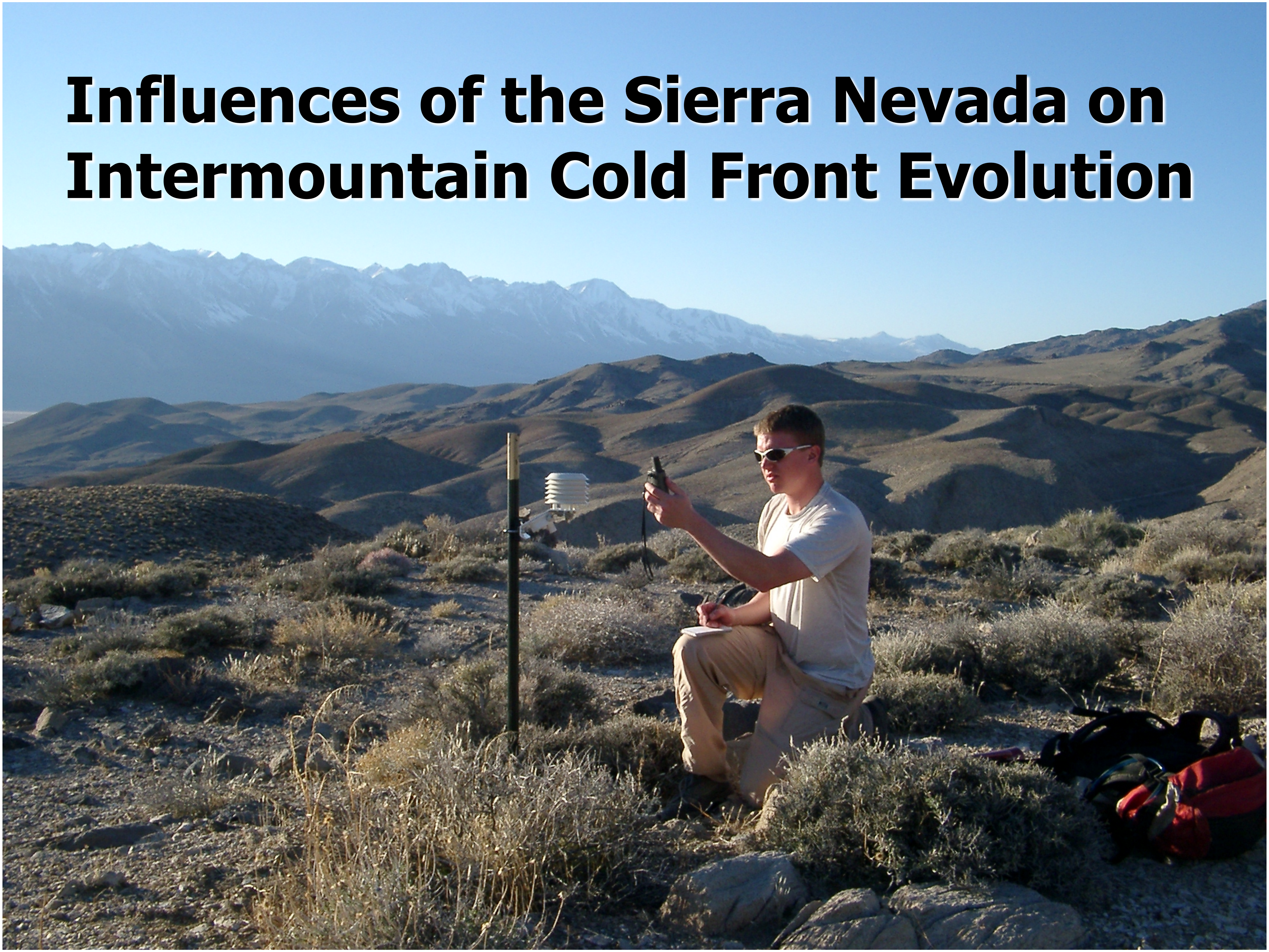
0.5 1.0 1.5 2.0
2100 UTC: 850 mb θ, wind, precip
288
304
2100 UTC: XY θ, wind, PV

CTL vs. Fake Dry

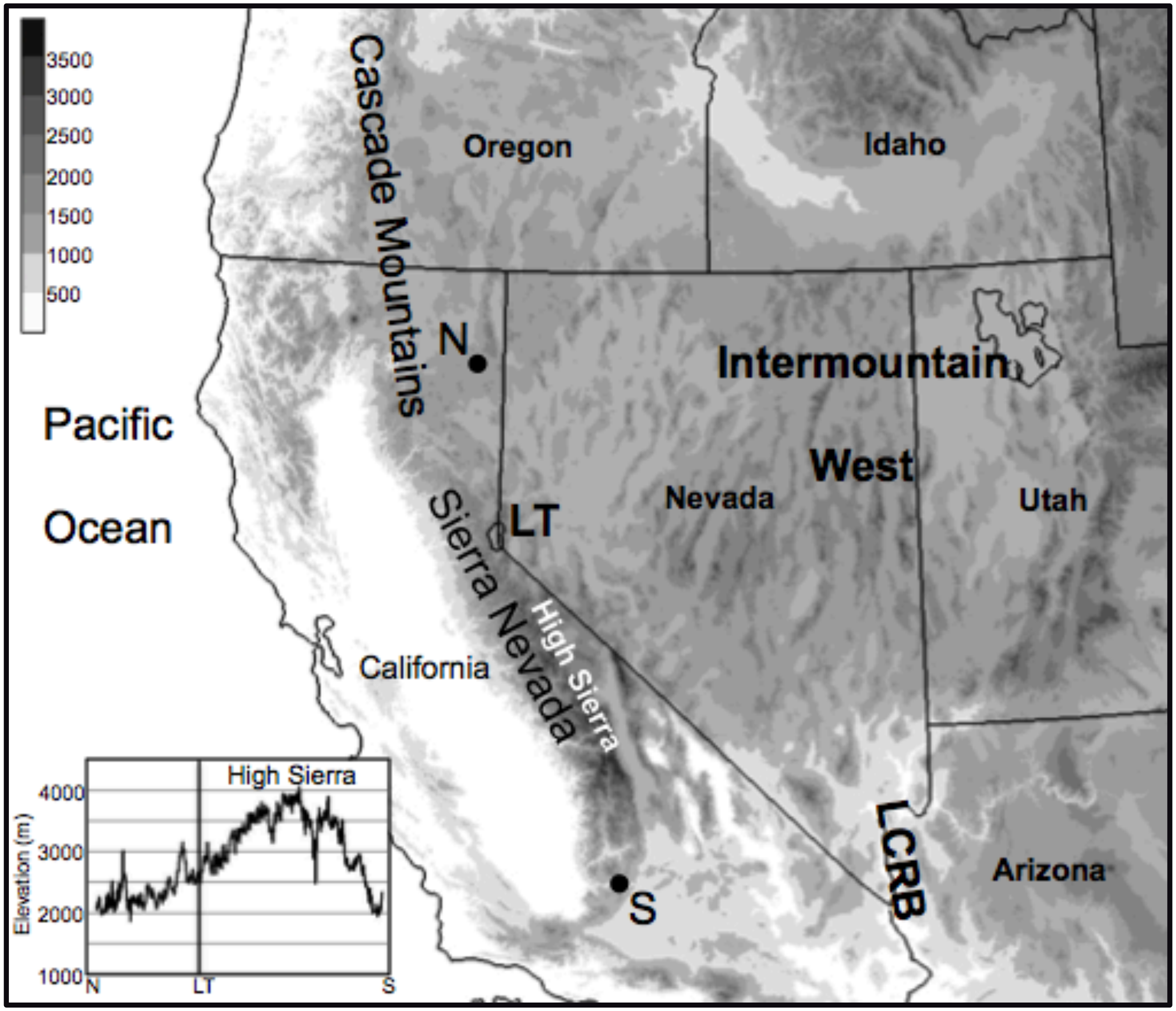


S&S Storm Conclusions

- First well documented case of discrete frontal propagation across western US
- Migration of upper-level PV anomaly encourages formation of new cold front from pre-existing baroclinity as troughing, confluence & convergence develop downstream of Sierra
  – More complex than 2-D idealized studies
- Moist diabatic processes sharpen front, but are not essential for discrete propagation

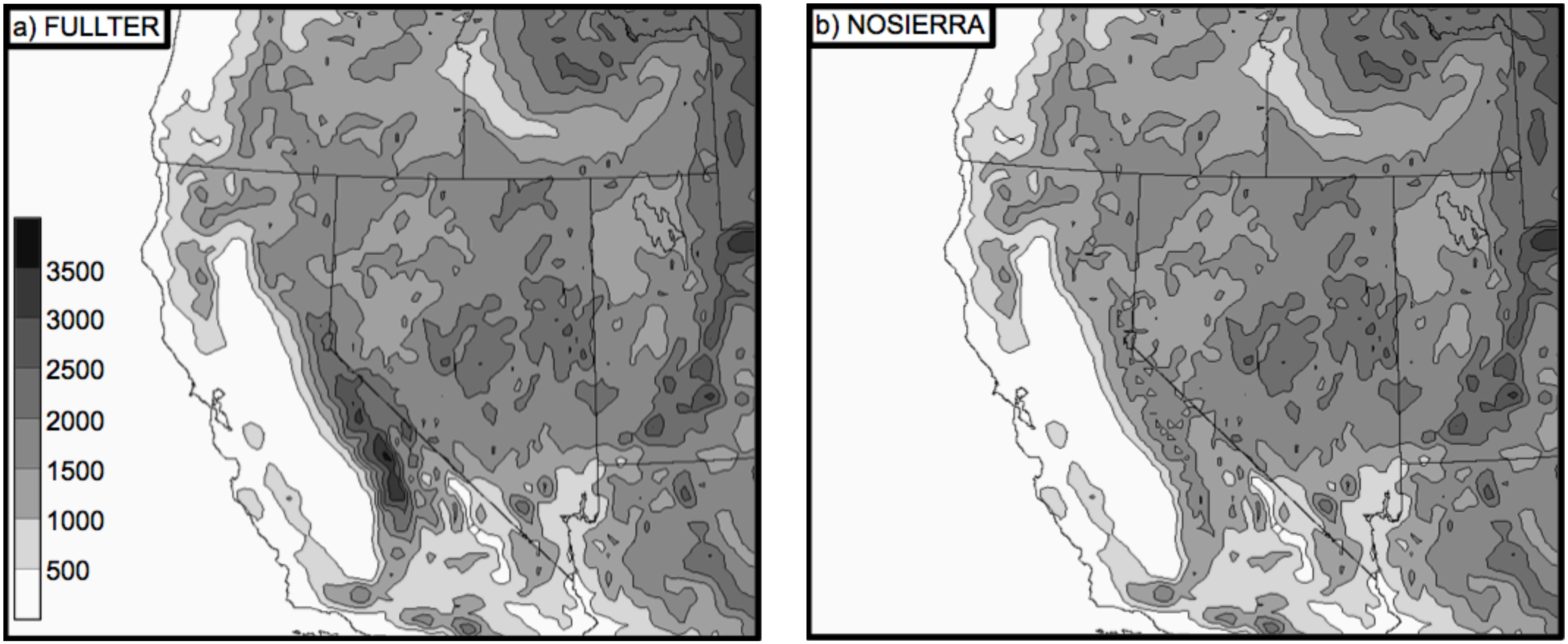

Influences of the Sierra Nevada on
Intermountain Cold Front Evolution

Sierra Nevada



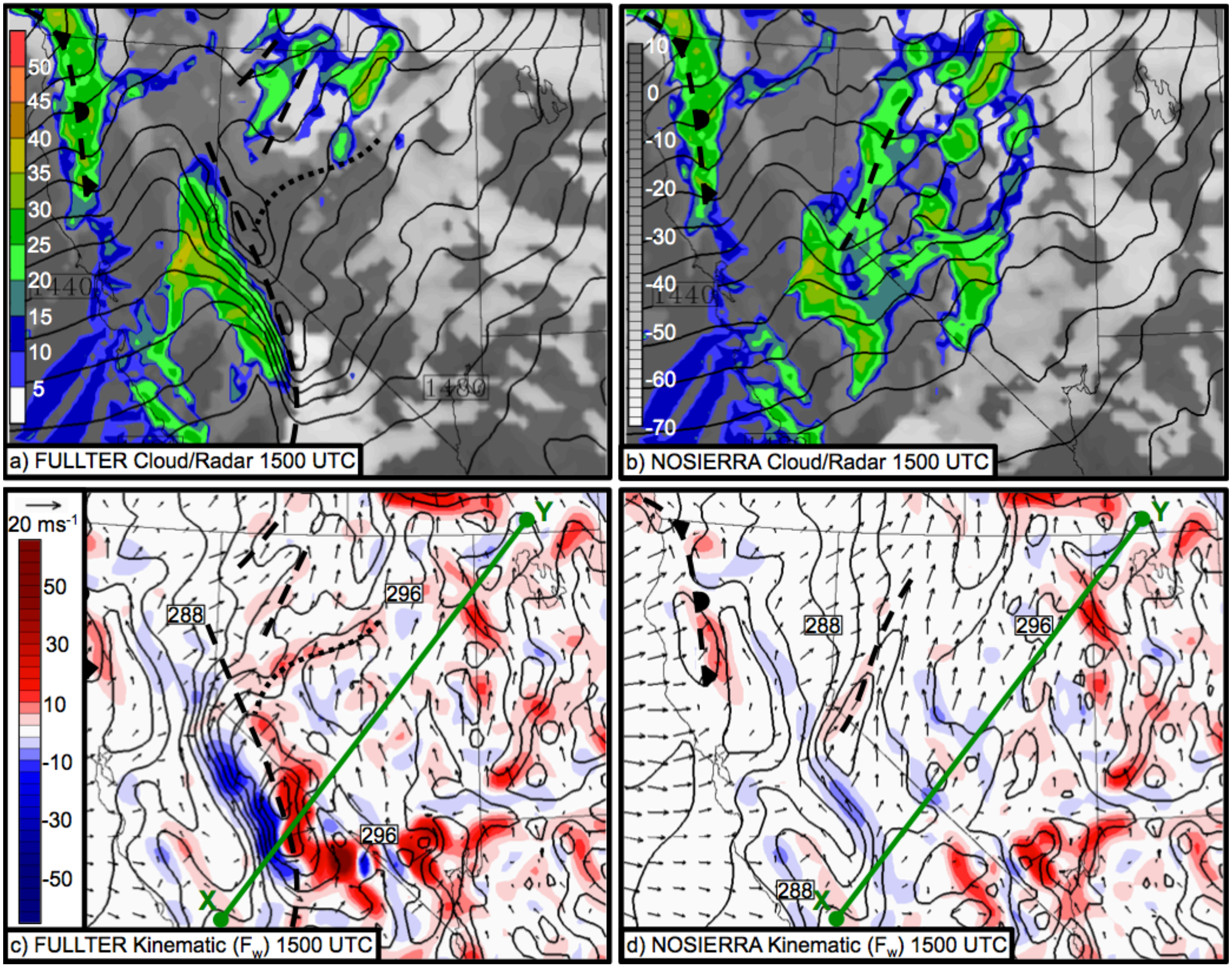
Sierra Nevada are a high barrier, especially southern "High" Sierra

Impacts of the Sierra

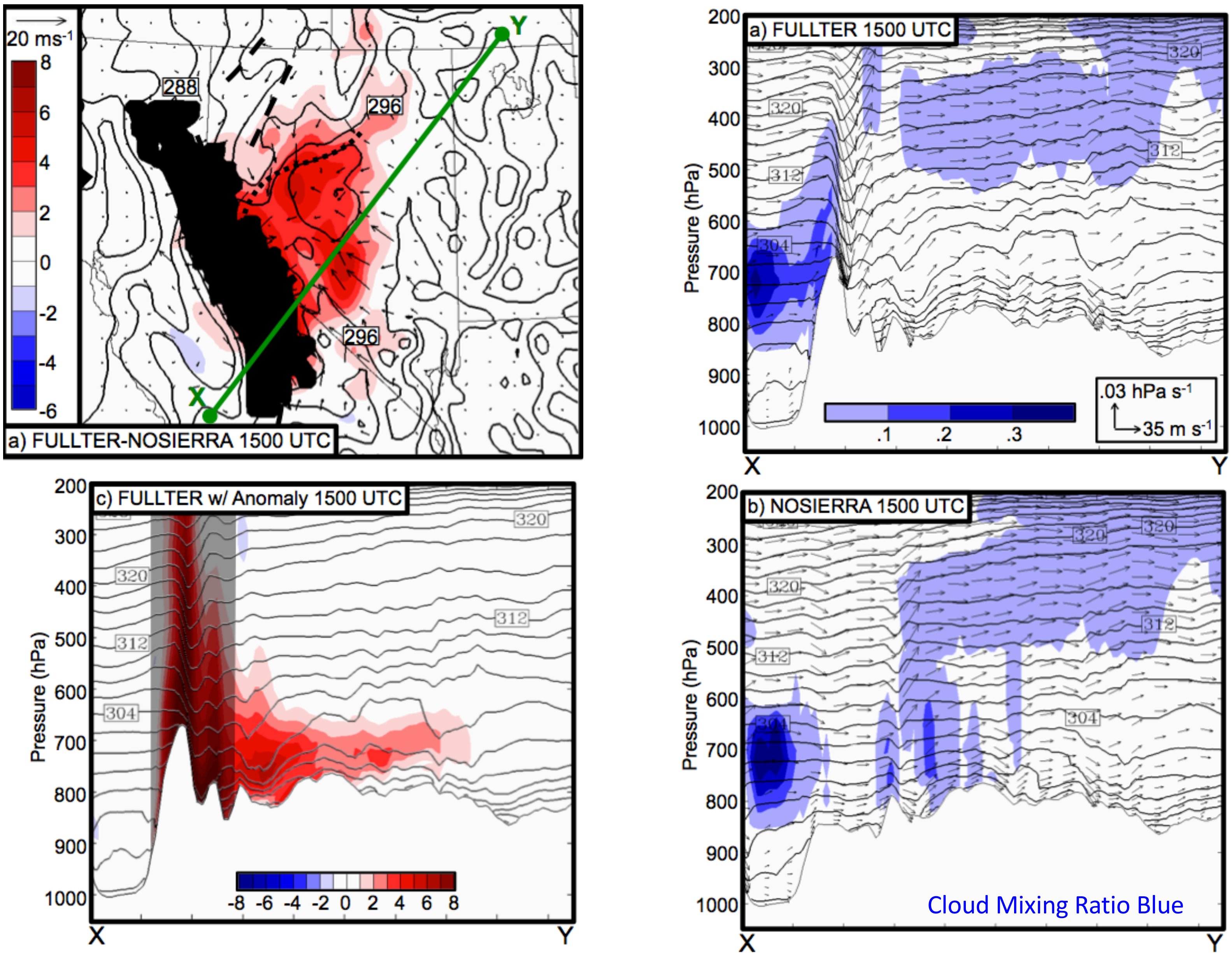


Compare WRF simulations with and without High Sierra
(i.e., topography > 1500 m)

Antecedent Conditions (1500 UTC)



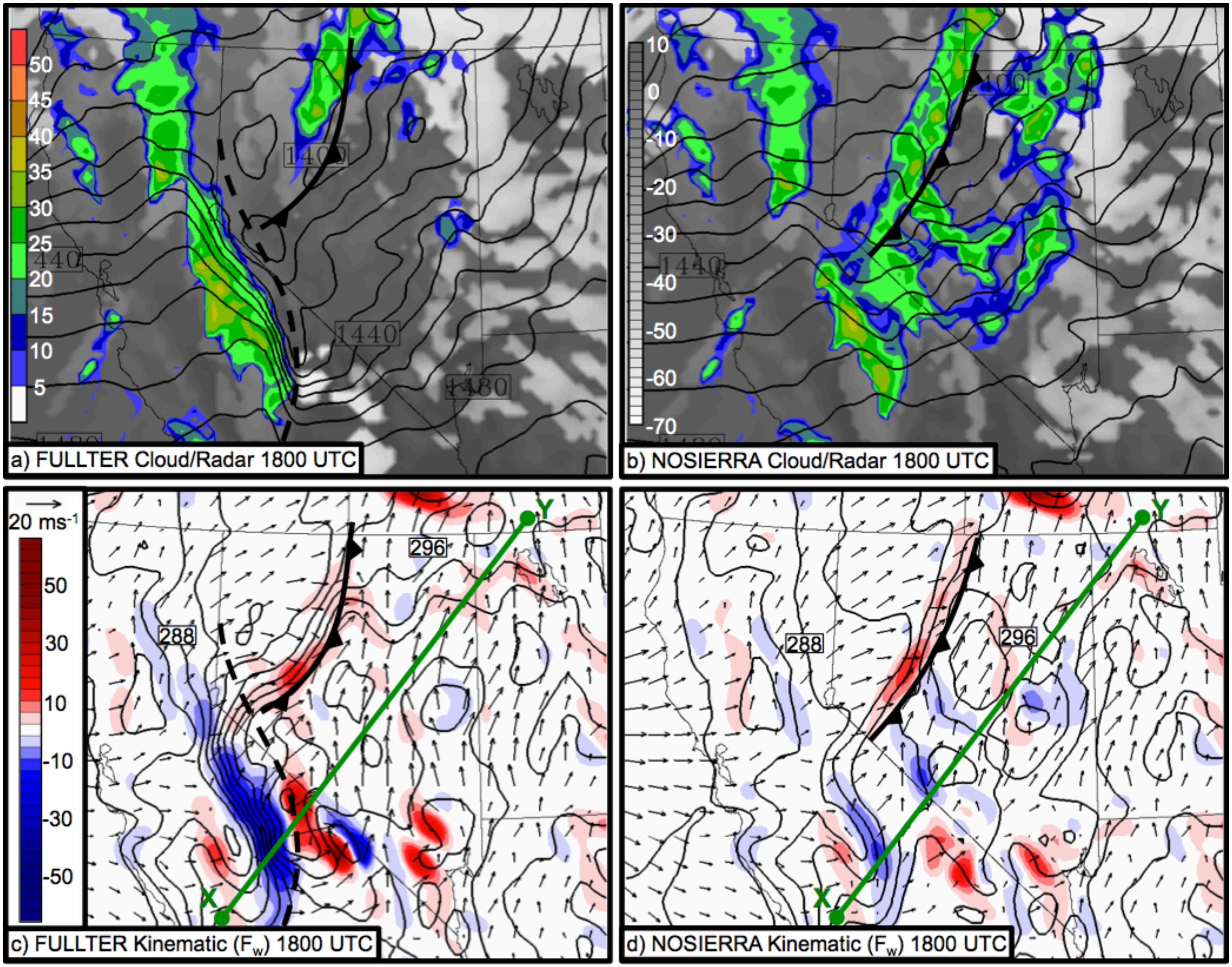
Antecedent Conditions (1500 UTC)



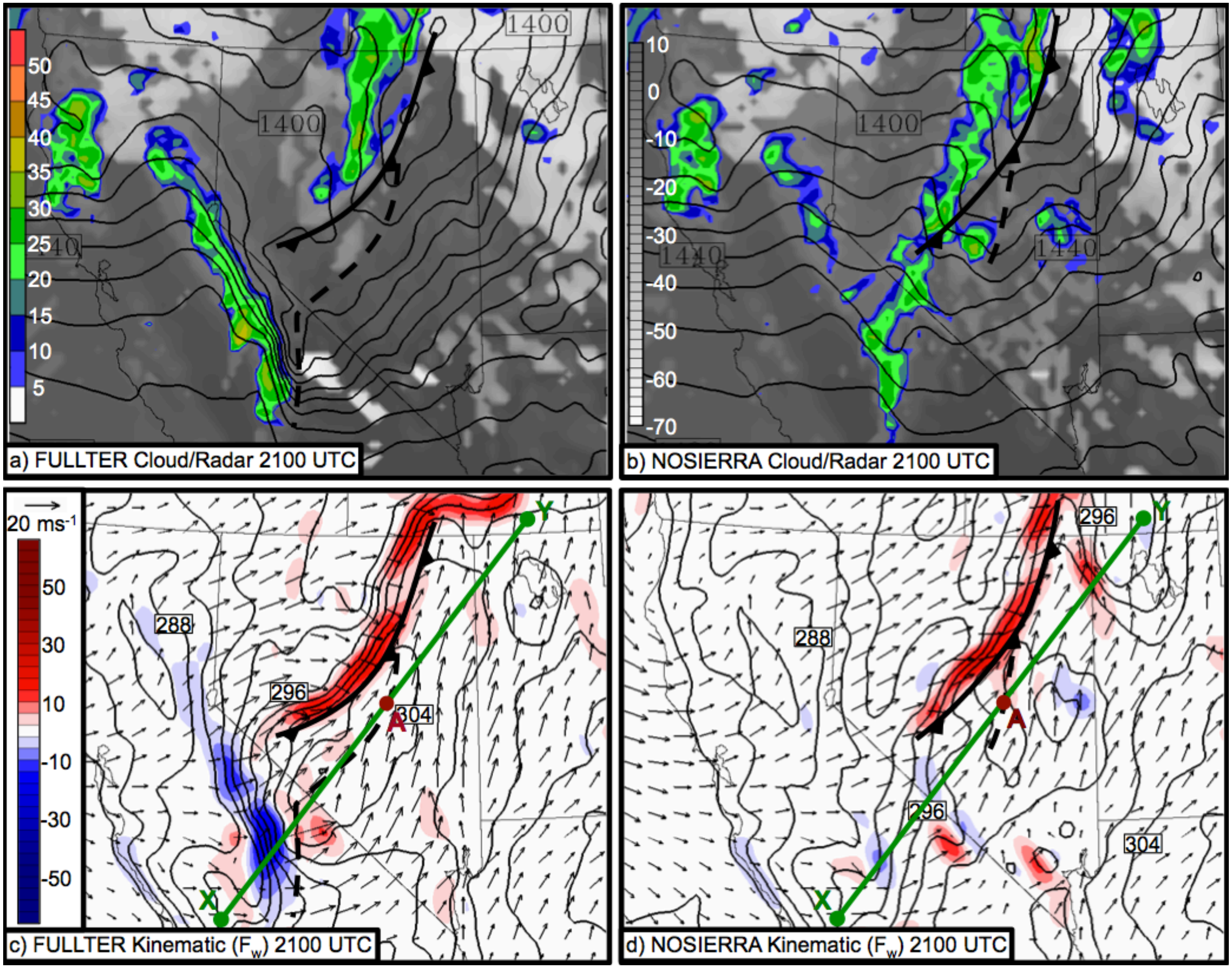
Warm Anomaly Mechanisms

- Blocking of eastward penetration of Pacific air into Great Basin
- Direct effects of airmass transformation (drying and warming of air traversing High Sierra due to orographic precipitation)
- Indirect effects of airmass transformation
  - Reduced sub-cloud evaporative and sublimational cooling due to less precipitation downstream of High Sierra
  - Increased sensible heating due to less cloud cover (occurs later in the day)

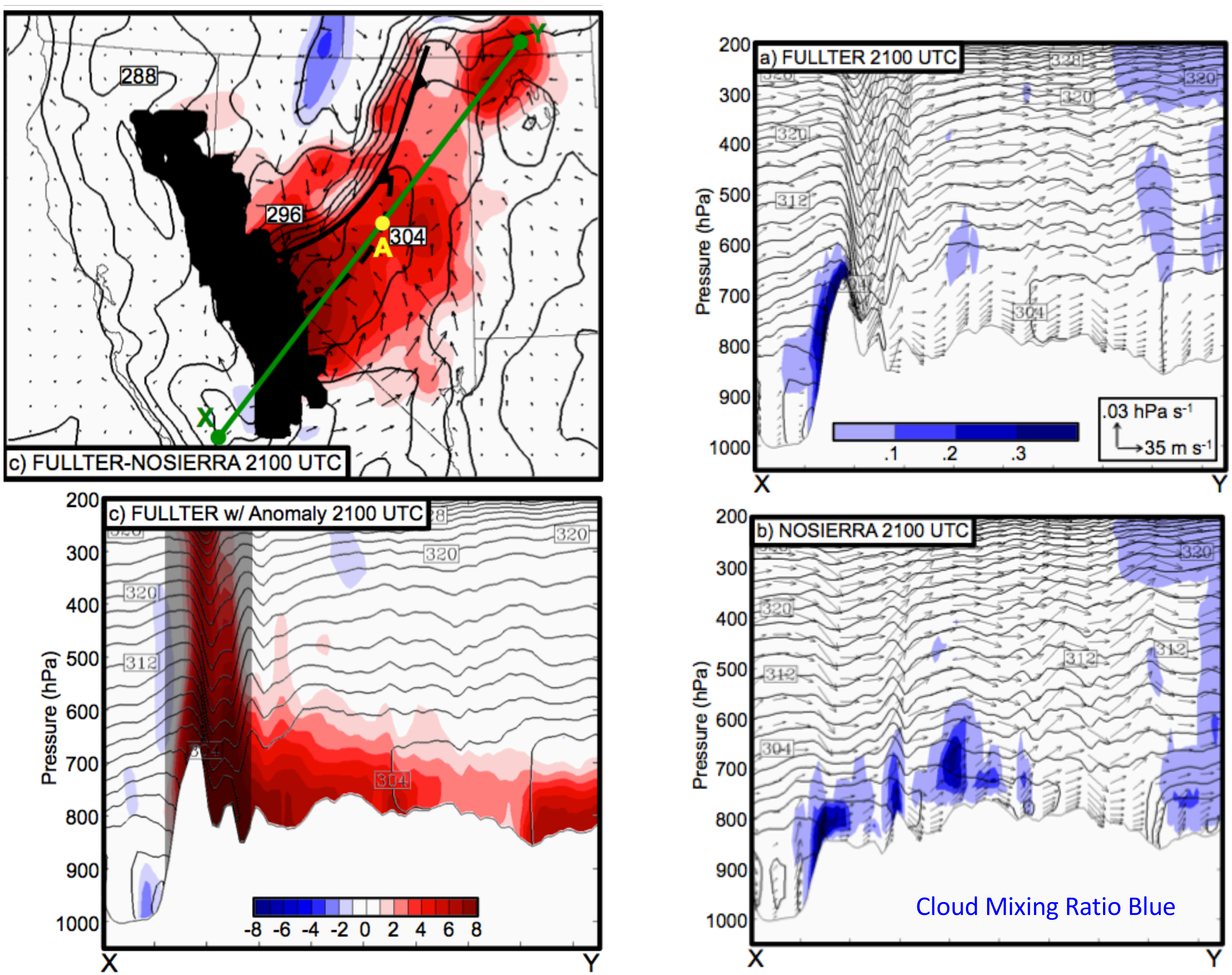
Frontal Development (1800 UTC)



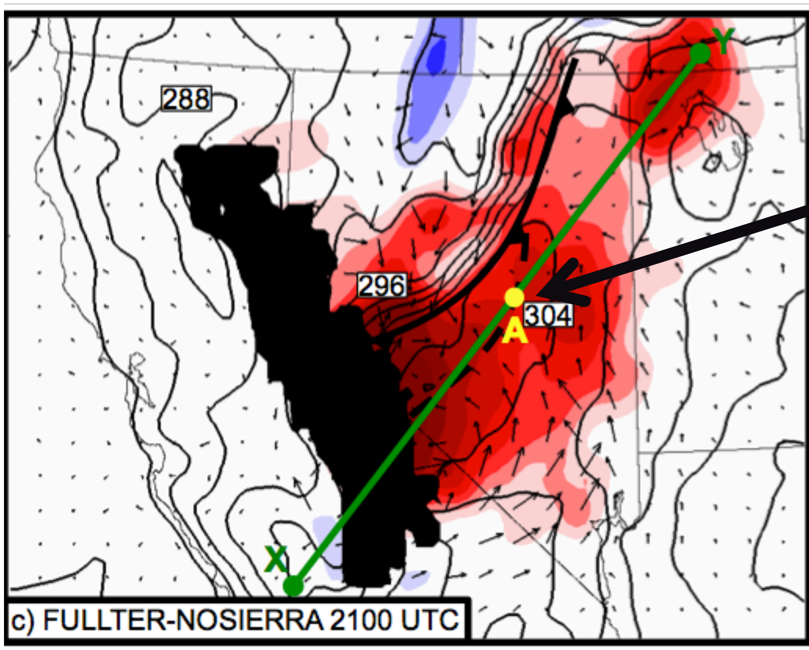
Frontal Development (2100 UTC)

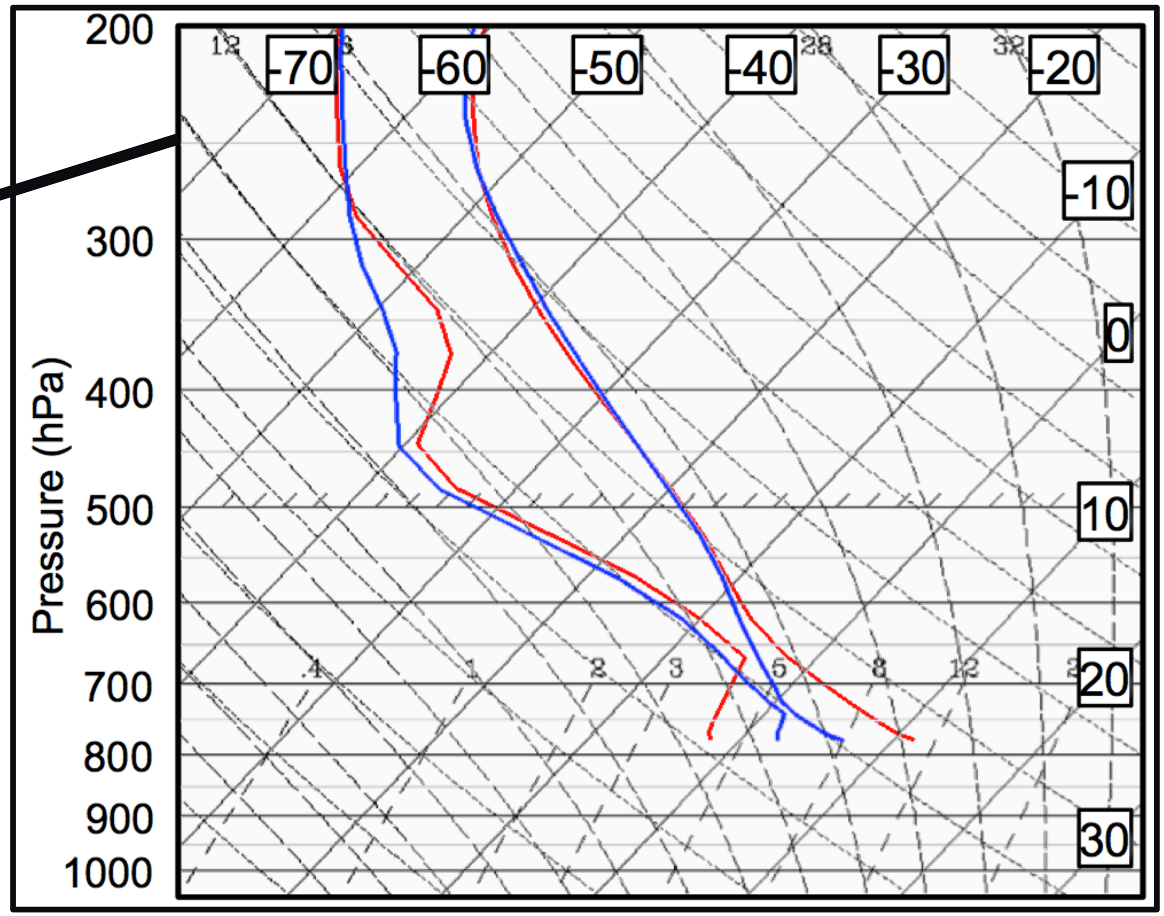


Frontal Development (2100 UTC)



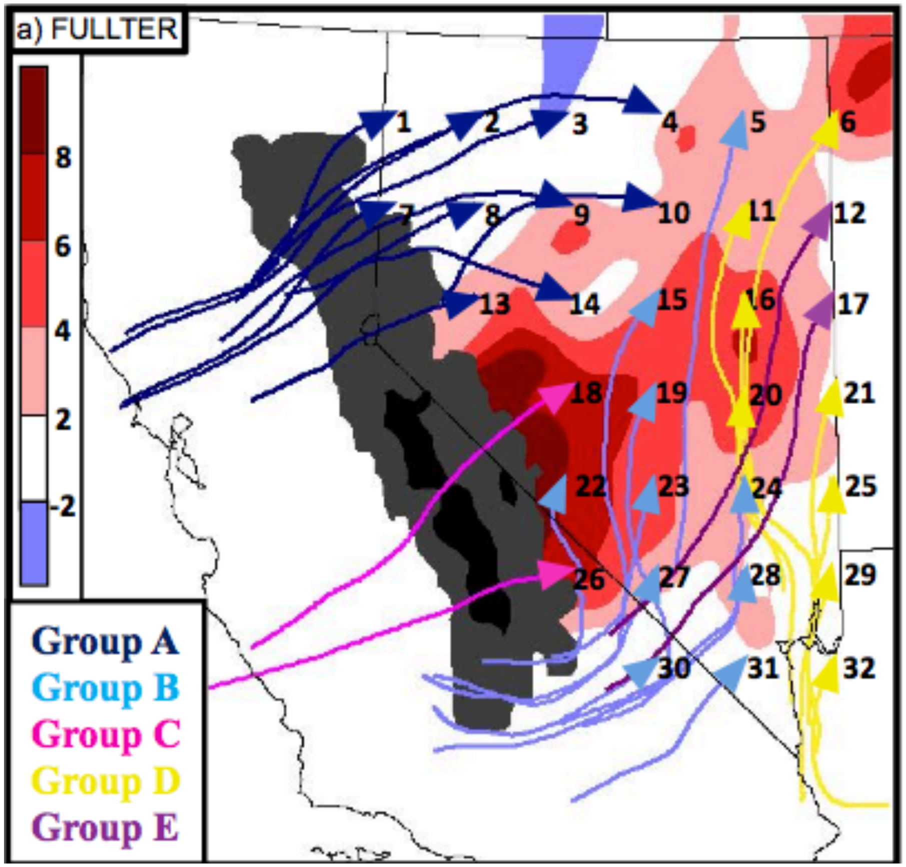
Frontal Development (2100 UTC)

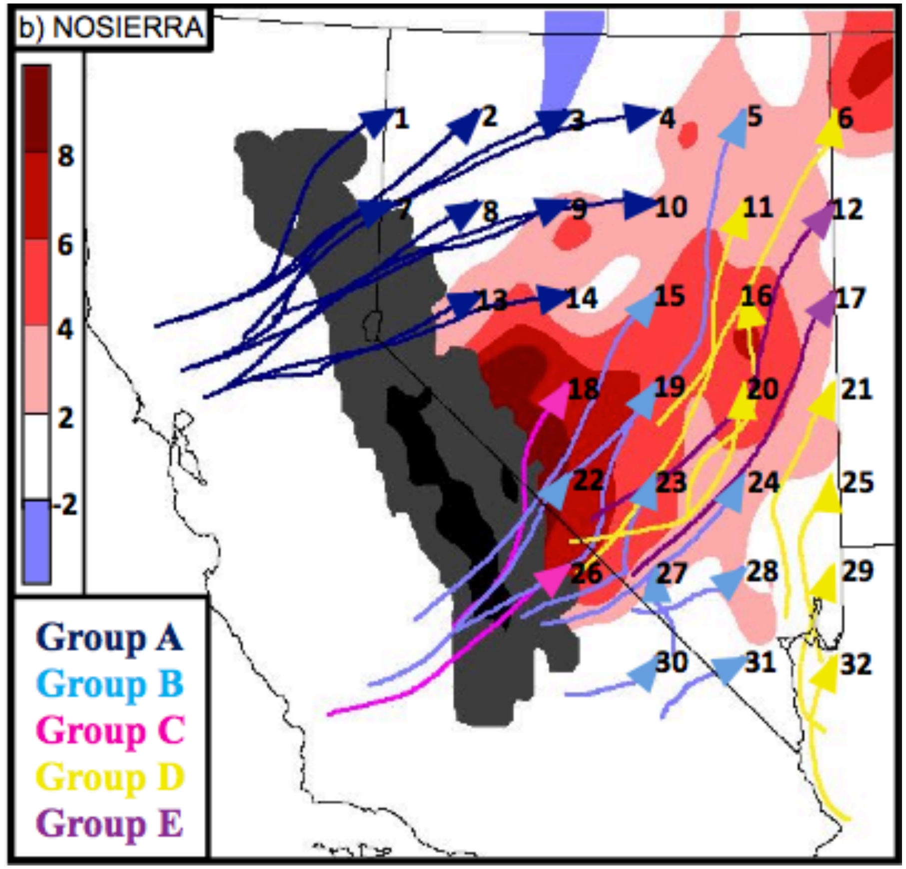




FULLTER=RED, NOSIERRA BLUE

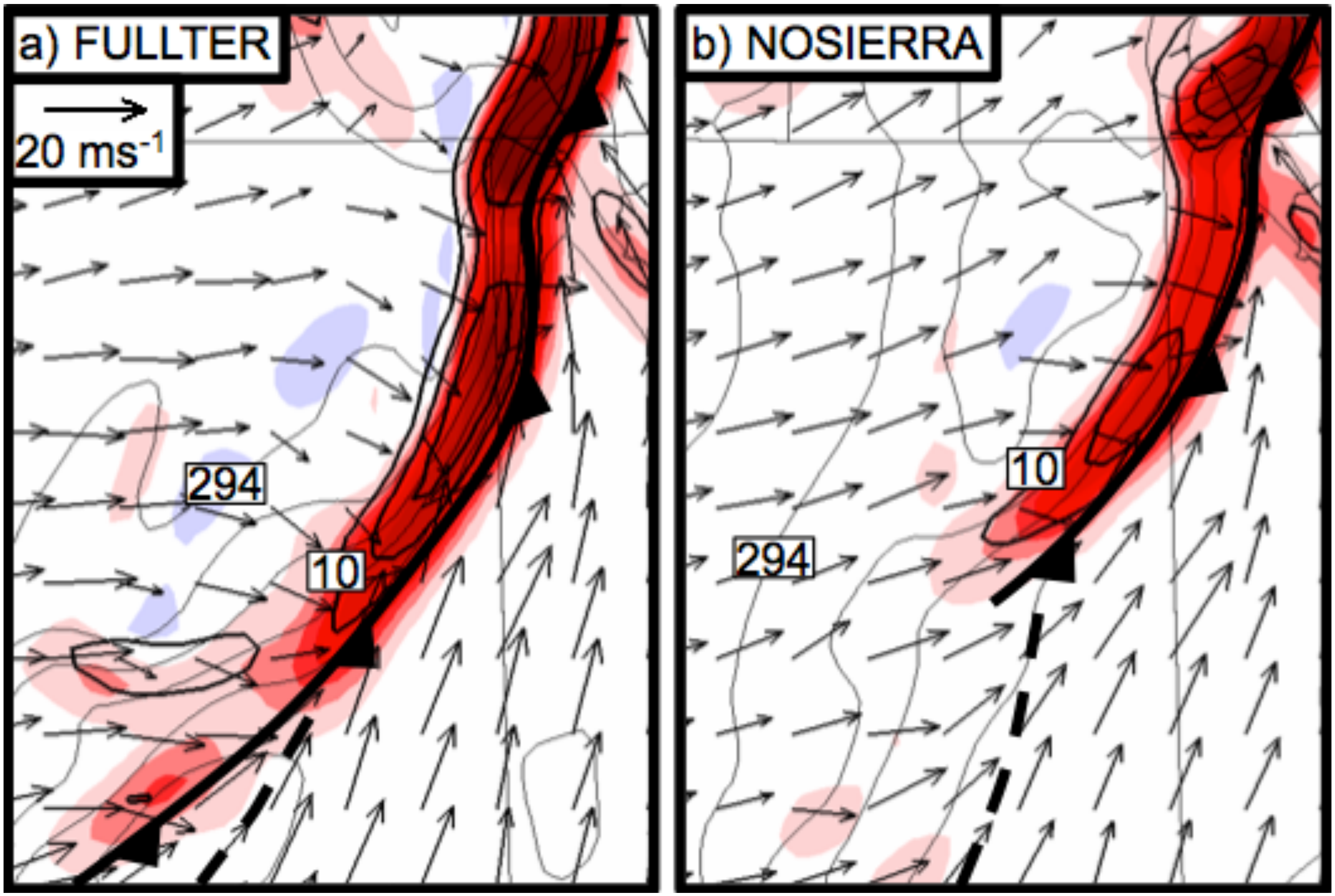
Trajectories





Selected Trajectory Group	Thermodynamic Summary
A	Θand ΔΘ similar in FULLTER and NOSIERRA
B	Θ increases in both, but increase is at least 3K greater in FULLTER than NOSIERRA due to reduced precip and cloud cover downstream of Sierra
C	Θ increases 10-12K in FULLTER, but <5K in NOSIERRA due to differences in airmass transformation and downstream sensible heating

Frontal Collapse



Intensity of temperature gradient also stronger in FULLTER Than NOSIERRA

Influences of the Sierra during SAS

- High Sierra produces downstream warm anomaly due to
  - Blocking of eastward penetration of pacific air
  - Direct effects of airmass transformation
  - Indirect effects of airmass transformation
    - Less downstream precip and increased downstream sensible heating
- Leads to stronger frontal collapse